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Comparative Study of Mechanical Properties and Water Absorption of Hybrid Unsaturated Polyester Composite Reinforced by Cinnamon Sticks and Banana Peel Powder with Jute Fiber

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ABSTRACT: This research intends to compare the flexural test, impact test, hardness shore D and water absorption for unsaturated polyester reinforced by 5% weight fraction fiber jute and different weight fractions (2%, 5%, 8%, and 11%) of cinnamon stick powder and banana peel powder. The hand lay-out technicality was utilized to fabricate these hybrid polymer composites. The recorded values were tabulated and statistically analyzed by using (SPSS 22) program, by using Tukey and Scheffe tests to determine the signification between the means of the test groups. The results display that the addition of cinnamon sticks powder and banana peel powder by (11% wt.) to unsaturated polyester resin - 5% wt. jute fiber improves the values of flexural strength, flexural modulus, toughness fracture, and hardness shore D, while this ratio weight fraction leads to a lower in the values of impact strength. The water absorption percentage of specimens increases with the increasing of the weight fraction of reinforcement material, but water absorption ratio decreases with decrease size particle, therefore, the specimens reinforced with cinnamon powder give water absorption percentage less than specimens reinforced with banana peels powder. The results of statistical analysis (SPSS) of mechanical properties and water absorption showed that the value of Sig was less than 0.05, which means that the addition of cinnamon powder and banana peel powder reinforced with jute fiber to unsaturated polyester was as positive.

KEYWORD: Unsaturated polyester; cinnamon stick powder; banana peel powder; mechanical tests; water absorption; Statistically analyzed.

INTRODUCTION

Natural fibers are sustainable and accessible material from natural resources that provide many characteristics, including acceptable quality, strength, low density, good sound reduction capacity, low cost, and high biodegradation [1]. Jute fibers and banana peel waste were distinguished importance in the engineering of composite materials due to their availability and the increasing demand for environmentally friendly materials. Many types of research have benefited from the potential to reinforce jute, bananas, flax, egg shells, and rice husks to develop thermoset composite materials utilize several various techniques, and these composite materials have been successful in semi-structural applications, automotive, transportation in addition to structural applications [2]. Polymeric composite reinforced with natural fibers is manufactured employ an industrial resin or natural, where there are many polymers that can be used as a base material for polymeric composite materials such as thermoset and thermoplastic [3], in that work, unsaturated polyester is utilized as a resin matrix and which among the industrial resins (thermoplastic polymers). The integration of two or more fillers into one matrix is called a "hybrid composite material", so properties of hybrid composite materials are average for individual components. The properties of polymeric hybrid composite depend on the many characteristics, like type and shape of the fiber, fiber content, the direction of the fiber, the interconnection between interface to the matrix and fiber and weight, volume fraction of fiber [4,5]. Optimal hybridization consequences are obtained when the fiber is greatly compatible. Many researchers have observed the effect of natural or industrial fillings reinforced with polymer resin on mechanical and physical properties to determine the application by which such hybrid composites are used. Prasada V.et.al. [6] the properties have been verified of jute and banana fibers with (5%-40% weight fraction) cashew nutshell as fillers with polyester resins. The results of tensile strength show that the specimen (UP+ jute and banana fiber+40% cns) has the highest value

compared with other weight fractions. Rafiquzzaman. M. et.al. [7] in this survey, the mechanical properties of three specimens 40% wt.jute fiber, 40% wt.glass fiber, and 10% wt. jute - 30% wt. glass fibers strengthened with epoxy resin were examined. The results display the incorporating of 10% wt.jute - 30% wt. glass fibers with epoxy resins giving maximum value to properties (tensile strength, bending strength and impact effect). Manimaran. P. et.al. [8] studied the effect of 10% wt. red banana peduncle with polyester resin, also 10% wt. red banana peduncle with 10% wt. wood flour/polyester resin on some mechanical properties. Consequences indicated incorporating 10% wt. red banana peduncle with 10% wt. wood flour/polyester resin gives maximum values to properties tensile, flexural and impact test. Ruaa H. and Reem A. [9] studied the tensile test, hardness shore D and absorption properties of epoxy resin supported by 4% - 16% wt. eggshells waste. The results showed that the specimen (ep.+16%wt. eggshells waste) had the highest value for the tensile test, hardness shore D and water absorption. This paper aims to, fabricate the hybrid biocomposite polymeric materials prepared from polyester resins filled with a different weight fraction of cinnamon powder and banana peel -and 5% wt. jute fibers. Determining which percentage of additives that led to an improvement in the flexural strength, flexural modulus, impact strength, toughness fracture, hardness of Shore D and water absorption compared to a sample without any fillers. These biocomposite polymeric materials can be used in automotive, ship and aircraft parts.

MATERIALS USED FOR RESEARCH

Use unsaturated polyester P-502 resin as a polymer base to prepare hybrid composites and Table 1 represents the properties of unsaturated polyester by the specifications of the supplier company (Deltech Europe Ltd. of Suffolk, England. Table 2 represents the characteristics of jute fiber [10] used as a filler to prepare specimens. Cinnamon stick powder and banana peel powder has been used as a filler material with unsaturated polyester in this research. Cinnamon powder is a tree belonging to the loireth family and is considered one of the most important spices used in daily life, cinnamon originally contains vital oils and other derivatives, such as aldehyde cinnamon, centamic acid and cinnamon [11]. Banana peels are agricultural waste and available in various locations, these agricultural wastes are the natural, renewable and environmentally friendly resource that can be used in many industrial fields and became a recycling of agricultural waste is now important [12]. The banana peels were cleaned with water and then dried in the air for several days and milled for 2 hours using an electric grinder to obtain a fine powder. Figure 1 (a-b) represents the steps taken to obtain cinnamon stick powder and banana peel powder. Figure 2 (a-b) presents the chemical composition examined using the fluorescent X-ray spectrometer for both the cinnamon stick powder and banana peels. Figure 3 (a-b) shows the average granular size of both cinnamon stick powder and banana peels powder, where the average granular size of cinnamon stick powder (29.05 μm), and the average granular size of banana husk powder was (35.22 μm).

Table 1. Unsaturated polyester properties according to supplier Company

Flexural strengthh	Flexural modulus	Tensile strength	Elongation tension	Density
85 MPa	3.6 GPa	56 MPa	2.0%	1.1 gm/cm^3

Table 2. Properties of jute fiber

Young Modulus	Tensile strength	Elongation at break	Density
10-30 Gpa	400-800 MPa	1.8%	1.46 gm/cm^3

(a)

a- Banana peels

b- Banana peels after washed in water and dried

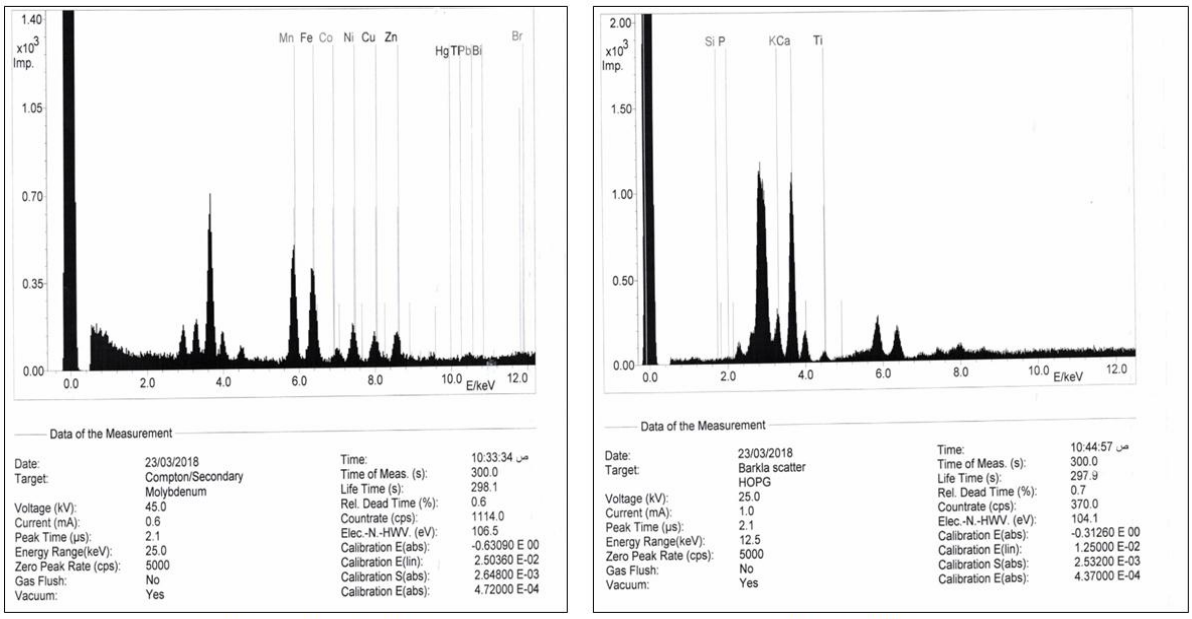
c- Mill used to grind the banana peels

d- Banana peels after milling for 2 hours

a- Cinnamon sticks | b- Mill used to grind the cinnamon sticks | c- Cinnamon after milling for 2 hours

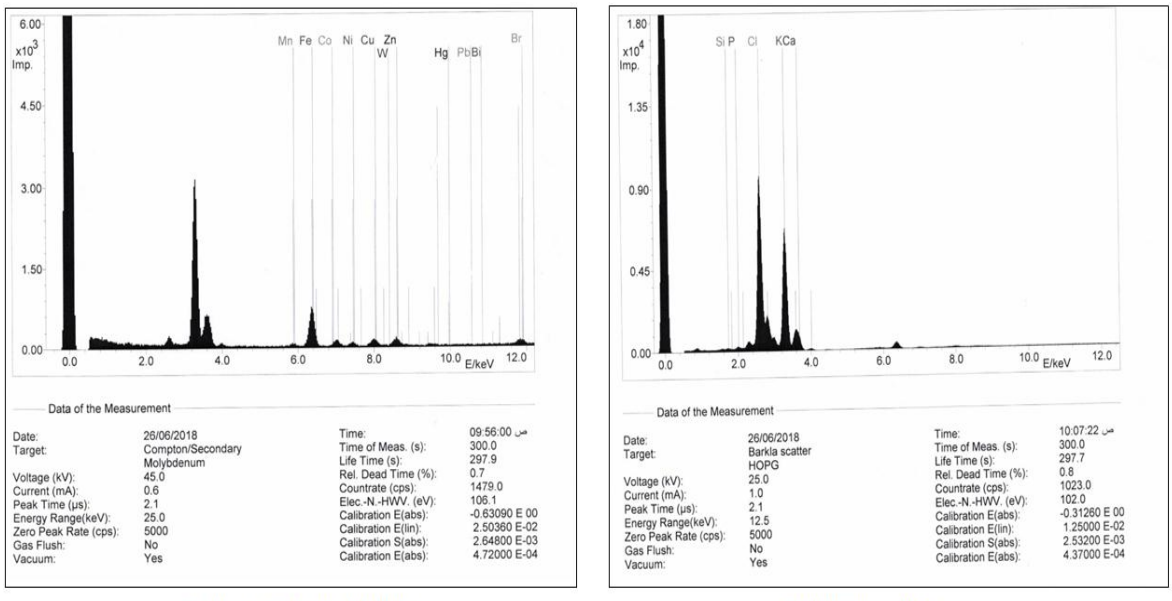
(b)

Figure 1. (a) Steps to preparing cinnamon stick powder, (b) Steps to preparing banana peels powder



Compton secondary molybdenum | Barkla scatters HOPG

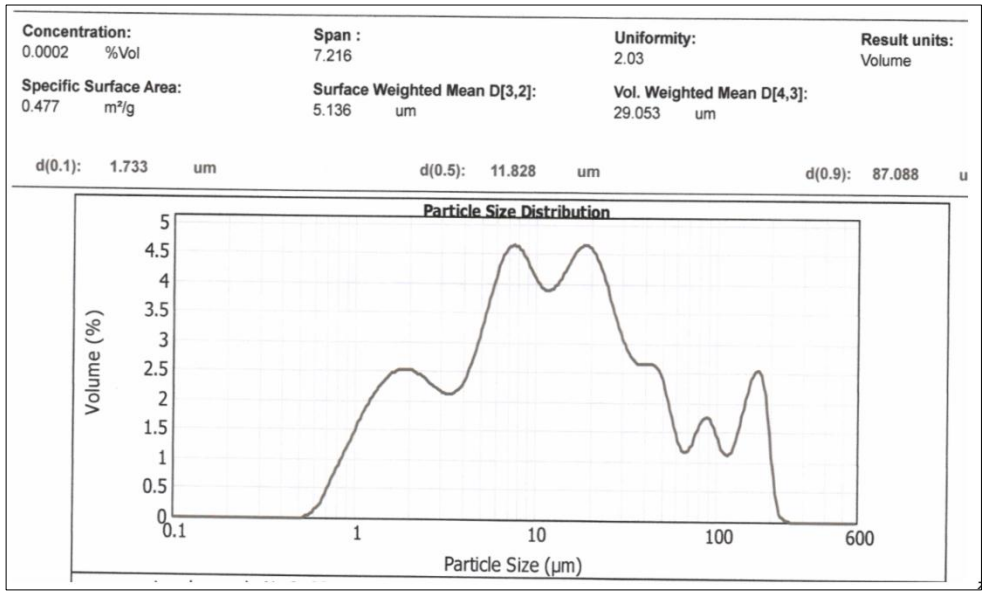
(a)



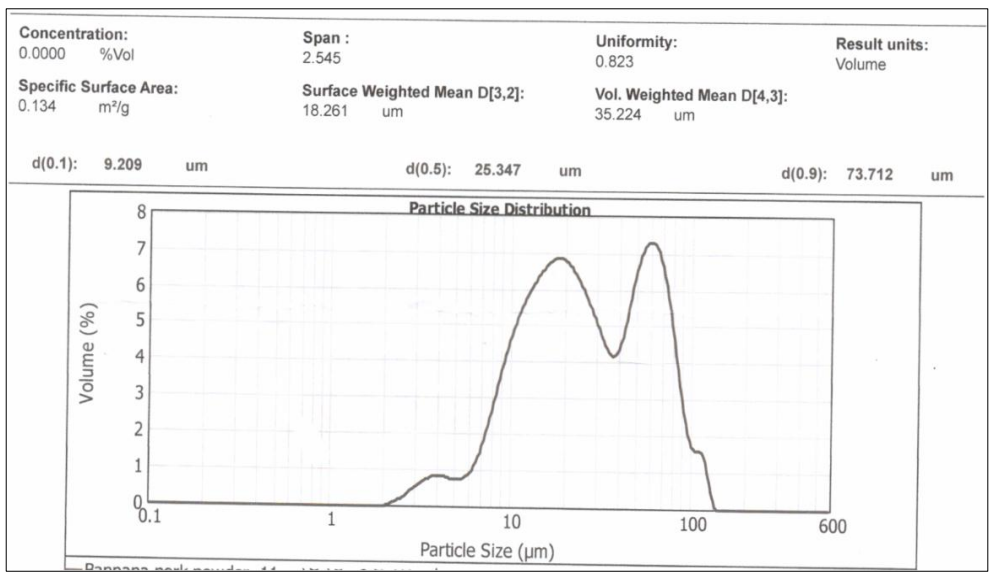
Compton secondary molybdenum | Barkla scatters HOPG

(b)

Figure 2. (a) X-ray Fluorescence of the elements existent in the cinnamon stick powder, (b) X-ray Fluorescence of the elements existent in the banana peels powder



(a)



(b)

Figure 3. (a) Average granular size of the cinnamon stick powder, (b) Average granular size of the banana peels powder

PREPARATION SPECIMENS REINFORCED WITH CINNAMON STICK POWDER AND BANANA PEELS POWDER

Hybrid composite specimens are prepared from 5% wt. jute fiber and 2%, 5%, 8%, 11% wt. of cinnamon stick powder and banana peel powder are added as filler to unsaturated polyester by utilize the hand lay-up molding method. The cutting of jute fibers depends on the size of the mold (17 x 17 x 0.5 cm^3). Specimens pure were prepared by mix-up unsaturated polyester with 2% wt. of the hardener. Specimens reinforced with cinnamon

stick powder and banana peel powder are prepared by mixing the specified percentage of the powder with resin solution and adding the specified percentage of the hardener to the mixture, then pouring it in the middle of the mold. Leave the mixture in the mold for 24 hours at room temperature from the starting of the mixing process as the working time to increase the viscosity of the mixture. Remove the specimens from the mold and put them in the oven at a temperature of 55 for 30 minutes for the purpose of removing residual stresses in samples [13,12]. Cutting at least three the specimens according to ASTM of flexural test D790, impact test ISO-180, hardens shore D-2240 and water absorption D-570 for each testing as shown in Figure 4. Table 3 present the details composition of the specimens.

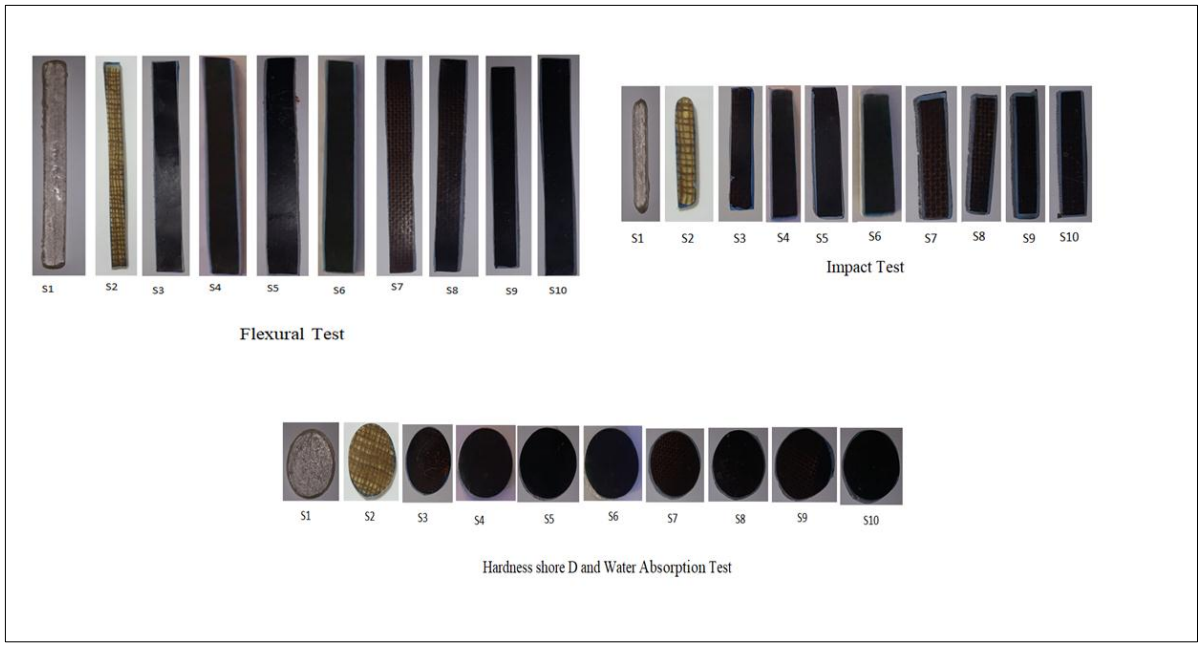


Figure 4. Specimens for flexural, impact and hardness shore D and water absorption

Table 3. Details composition of the specimens

Specimens	**Composition (wt.)**
S1	Pure unsaturated polyester
S2	UP+5% Jute fiber
S3	UP+5% Jute fiber + 2% cinnamon stick powder
S4	UP+5% Jute fiber + 5% cinnamon stick powder
S5	UP+5% Jute fiber + 8% cinnamon stick powder
S6	UP+5% Jute fiber + 11% cinnamon stick powder
S7	UP+5% Jute fiber + 2% banana peels powder
S8	UP+5% Jute fiber + 5% banana peels powder
S9	UP+5% Jute fiber + 8% banana peels powder
S10	UP+5% Jute fiber + 11% banana peels powder

TEST PROPERTIES

Flexural Test

The dimensions of the specimens for the flexural test are L=191mm, W= 13mm, and T4.8=mm according to ASTM D-790i [15]. The flexural strength and flexural modulus can be calculated from equation 1and 2 [16, 17].

$$F.S = \frac{3PL}{2bd^2} \qquad 1 \text{ [16]}$$

Where

F.S: flexural strength MPa
P: force N
L: length sample mm
B: thickness sample mm
d: widthisample mm

$E_B = \frac{L3\ P}{4bd3\ \delta}$ 2 [17]

Where:
Eb: Flexural modulus MPai
L: support span mm
P: load applied,N
b: width of sample,mm
d: thickness of sample,mm
δ: deflection

Impact Test

The dimensions of specimens for the impact test are L=80mm, W=10mm and T=4mm according to standard (ISO-180) at room temperature [18]. The impact strength and fracture toughness can be calculated, from equation 3 and 4 [19].

$Gc = \frac{Uc}{A}$ 3 [19]

Where;
Gc**:** toughness of material J/m^{2}2
Uc**:** impact energy JJ
A: cross- sectional area of sample m^{22}

$Kc = \sqrt{Gc.Eb}$

Where;
Kc: fracture toughness MPa.m$^{1/2}$
Gc: toughness of material J/m^2
Eb: flexural modulus MPa

Hardness Shore D

The dimensions of specimens for the hardness shore D are 4 cm diameter and 0.5 cm thickness according to ASTM D-2240, at room temperature [20].

Water Absorption

The dimensions of specimens for the water absorption are 4cm diameter and 0.5 cm thickness according to ASTM D 570 at room temperature,[21]. The water absorption can be calculated from equation 4 [22].

$M\ \% = \frac{Mt-M0}{M0} \times 100$ 4 [22]

Where;
M %**:** water absorption percentage
M_t: mass of specimen after immersion for seven days g
M_o: mass of specimen before immersion g

STATISTICAL ANALYSES OF DATA

Statistical analysis of the results for each test was conducted using a one-way analysis of variance followed by (Tukey's posthoc, and Scheffe) with significance denoted at $P \leq 0.05$ by using the SPSS 22 program [23].

RESULTS

Flexural Properties

Table 4 Figure 5 displays the results of flexural strength obtained from the flexural test for specimens prepared

from jute fiber-cinnamon stick powder and banana peels powder with unsaturated polyester resin. The specimens (5%wt. jute fiber - unsaturated polyester) have better flexural strength than pure unsaturated polyester because the mechanical properties of jute fibers are better than unsaturated polyester alone. Flexural strength increase with decrease average granular size and increasing weight fraction of fillers, therefore, the flexural strength of the specimens enhanced with cinnamon stick powder were higher compared to the specimens enhanced with banana peels powder, this agrees with reference [16]. The minimum and maximum values flexural strength for both specimens reinforced with cinnamon stick powder and banana peels powder (118±3.035, 112±2.050 MPa) and (204±2.050, 199±4.041Mpa) respectively. As described earlier, it has been investigated that the higher weight fraction of the fillers give better compatibility and dispersion in hybrid composites, thereby improving stress transfer capacity in hybrid vehicles [24]. Since both the cinnamon stick powder and banana peels powder have got almost equal extensibility, the stress transferred from fiber and filler to another during the matrix can be propagated without any failure to the hybrid composites and thus improve flexural strength.

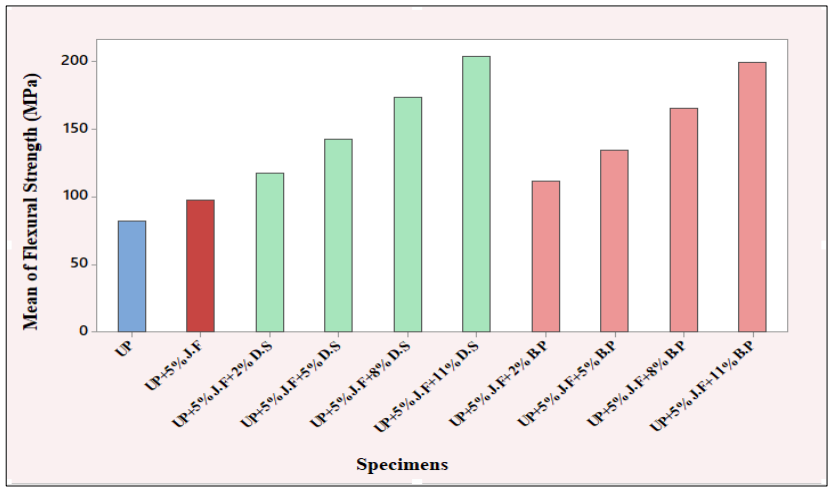


Figure 5. Results flexural strength of all specimens

Specimens	N	Mean (MPa)	Std. Deviation	Minimum	Maximum	Sig.

Table 4. Results flexural strength for all specimens

UP	3	82	2.000	80	84	0.9
UP+5%J.F	3	98	3.010	95	101	0.7
Specimens with cinnamon stick powder						
UP+5%J.F+2%D.S	3	118	3.035	115	121	0.4
UP+5%J.F+5%D.S	3	143	3.050	140	146	0.3
UP+5%J.F+8%D.S	3	174	3.094	171	177	0.2
UP+5%J.F+11%D.S	3	204	4.000	200	208	0.01
Specimens with banana peels powder						
UP+5%J.F+2%B.P	3	112	2.050	110	114	0.5
UP+5%J.F+5%B.P	3	135	2.528	133	136	0.4
UP+5%J.F+8%B.P	3	166	3.075	163	169	0.3
UP+5%J.F+11%B.P	3	199	4.041	195	203	0.02

The flexural modulus of the cinnamon stick powder and banana peels powder - jute fiber with unsaturated polyester are illustrated in Table 5 and Figure 6. The flexural modulus increased significantly from 3.333±.2517 to 4.500±.3000 when jute fibers added by 5% wt., because the flexural modulus value for jute fiber higher than unsaturated polyester resin [25].The flexural modulus increased by 4.8%, 7.3%, 9.7% and 12.6% for specimens (UP+5% jute fiber +2%, 5%, 8% and 11% cinnamon stick powder) respectively, and flexural modulus increased by 2.8%, 4.3%, 6.7% and 9.6% for specimens (UP+5% jute fiber +2%, 5%, 8% and 11% banana peels powder) respectively, compared to the specimens without filler. Noted the specimens reinforced with a cinnamon stick powder have properties of flexural modulus better than specimens reinforced with banana peels powder, this depends on the nature of the chemical composition of both the filler materials and the average granular size [26]. Also, the presence of filler (11% wt. cinnamon stick powder and banana peel powder) are forming a good interface between the matrix and the filler material to transfer the stress [11].

Table 5. Results flexural modulus for all specimens

Specimens	N	Mean (GPa)	Std. Deviation	Minimum	Maximum	Sig.
UP	3	3.333	.2517	3.1	3.6	0.10
UP+5%J.F	3	4.500	.3000	4.2	4.8	0.8
Specimens with cinnamon stick powder						
UP+5%J.F+2%D.S	3	6.700	.2000	6.5	6.9	0.09
UP+5%J.F+5%D.S	3	7.600	.2015	7.4	7.8	0.07
UP+5%J.F+8%D.S	3	8.700	.2030	8.5	8.9	0.03
UP+5%J.F+11%D.S	3	10.400	.2045	10.2	10.6	0.001
Specimens with banana peels powder						
UP+5%J.F+2%B.P	3	5.700	.2088	5.5	5.9	0.010
UP+5%J.F+5%B.P	3	6.567	.1528	6.4	6.7	0.08
UP+5%J.F+8%B.P	3	7.533	.2535	7.3	7.8	0.04
UP+5%J.F+11%B.P	3	8.700	.2098	8.5	8.9	0.002

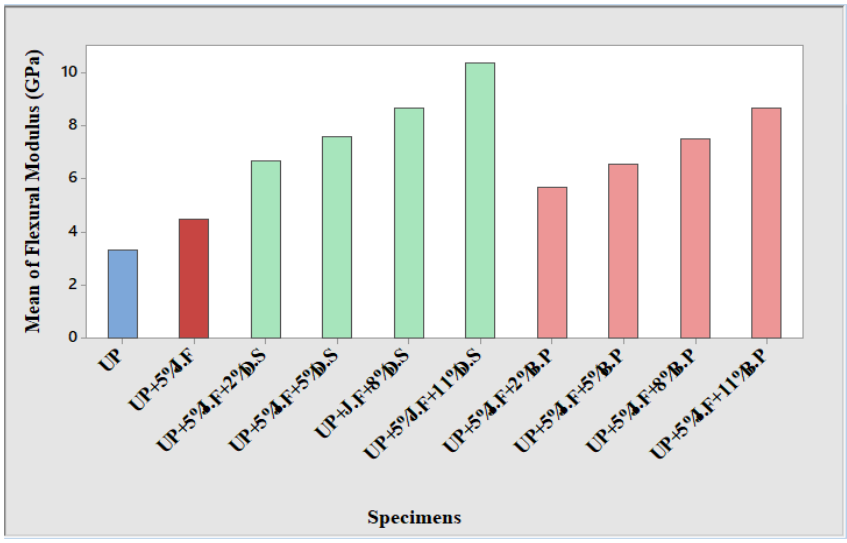


Figure 6. Results flexural modulus of all specimens

Impact Test

Table 6 and Figure 7 compares the impact strength of different hybrid composite specimens based on the weight fractions of cinnamon stick powder and banana peels powder reinforced with jute fiber and polyester resin. Of the Figure, observed that the specimens reinforced with (cinnamon stick powder and banana peels powder) are performing better than specimens without any filler. The impact strength increase with addition cinnamon stick powder and banana peels powder from (2% to 8% wt.), where the maximum impact strength is obtained for specimen (UP+5% j.f+8% D.S) (11.9200 ±.04000) followed by (UP+5% j.f+8% B.P) (11.3300±.03000). The impact strength of hybrid composite depends on many factors such as the type of the matrix, the natural interconnection between the matrix- fiber, and the size of the particle filler. Among these factors, we find that fillers material is important for absorbing and dispersing more energy and preventing cracks from starting more effectively [27, 28]. Noted from these results that the increase of the weight fraction to (11%) leads to a decrease in the impact strength because this percentage leads to increased fragility with reducing the interconnection between the matrix and the fillers [7, 29].

Table 6. Results impact strength for all specimens

Specimens	N	Mean	Std. Deviation	Minimum	Maximum	Sig.
UP	3	7.1100	.02000	7.09	7.13	0.11
UP+5%J.F	3	8.8900	.03000	8.86	8.92	0.9
Specimens with cinnamon stick powder						
UP+5%J.F+2%D.S	3	9.8500	.05000	9.80	9.90	0.07
UP+5%J.F+5%D.S	3	10.7500	.03000	10.72	10.78	0.05
UP+5%J.F+8%D.S	3	11.9200	.04000	11.88	11.96	0.03
UP+5%J.F+11%D.S	3	11.4500	.03000	11.42	11.48	0.01
Specimens with banana peels powder						
UP+5%J.F+2%B.P	3	9.5500	.05000	9.50	9.60	0.09
UP+5%J.F+5%B.P	3	10.2300	.03000	10.20	10.26	0.08
UP+5%J.F+8%B.P	3	11.3300	.03000	11.30	11.36	0.04
UP+5%J.F+11%B.P	3	11.2000	.05000	11.15	11.25	0.02

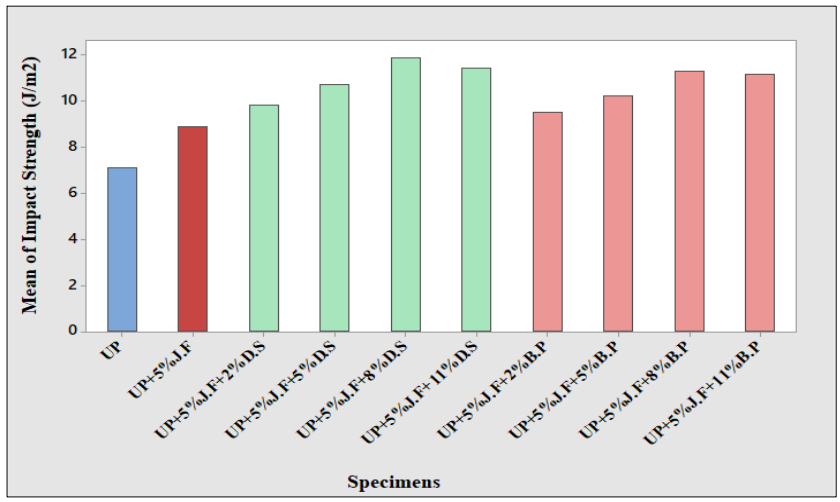


Figure 7. Results impact strength of all specimens

Fracture toughness is a measurement of resistance to crack spread through the material. Fracture toughness results of specimens hybrid composite specimens are shown in Table 7 and Figure 8.We derive from the results that the fracture toughness is increased with the addition of the weight fracture (cinnamon stick powder and banana peels powder), where the maximum fracture toughness is obtained for specimen (UP+5% j.f+11% D.S) (10.8867 ±.09504) followed by (UP+5% j.f+11% B.P) (9.8667±.12662). For hybrid composites, fracture toughness depends on other factors related to the distribution of reinforcement material, applied stress, the size of the material and the composition filler [30]. Therefore, the presence of filler has improved the nature of the interconnection between resin and reinforcement.

Table 7. Results fracture toughness for all specimens

Specimens	N	Mean	Std. Deviation	Minimum	Maximum	Sig.
UP	3	4.8300	.10000	4.73	4.93	0.14
UP+5%J.F	3	6.4900	.14731	6.33	6.62	0.12
Specimens with cinnamon stick powder						
UP+5%J.F+2%D.S	3	8.2800	.15100	8.12	8.42	0.08
UP+5%J.F+5%D.S	3	9.2900	.15000	9.14	9.44	0.06
UP+5%J.F+8%D.S	3	10.4333	.13577	10.29	10.56	0.001
UP+5%J.F+11%D.S	3	10.8867	.09504	10.79	10.98	0.004
Specimens with banana peels powder						
UP+5%J.F+2%B.P	3	7.3667	.12662	7.23	7.48	0.09
UP+5%J.F+5%B.P	3	8.1900	.08185	8.10	8.26	0.07
UP+5%J.F+8%B.P	3	9.2300	.14107	9.10	9.38	0.004
UP+5%J.F+11%B.P	3	9.8667	.12662	9.73	9.98	0.009

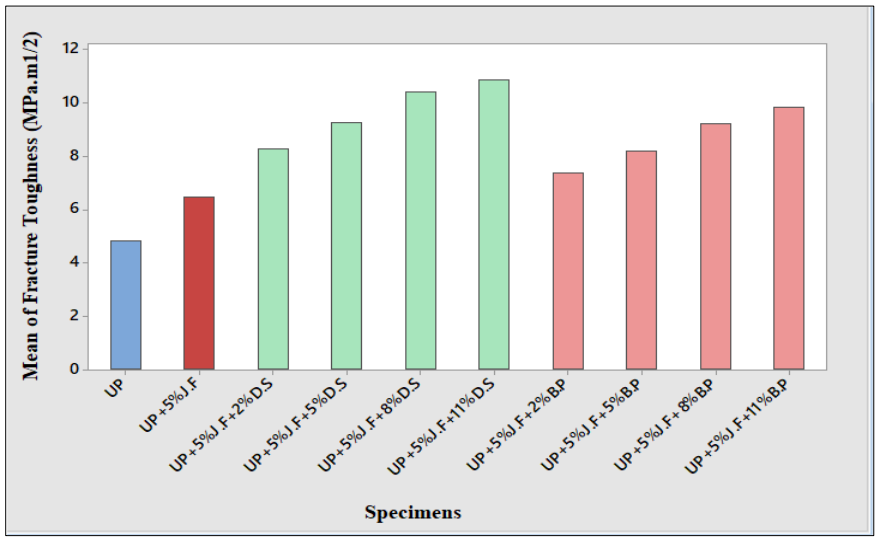


Figure 8. Results fracture toughness of all specimens

Hardness D

Table 8 and Figure 9 represent the results of the hardness shore D of the hybrid composite specimens, we noted from the results below that the values of hardness shore D increased after the strengthening of polyester unsaturated with jute fiber and cinnamon stick powder and banana peels powder. The best hardness values were in the specimens (UP+5% j.f+11% D.S) (87.667±.8055) followed by (UP+5% j.f+11% B.P) (87.600±.7550) compared with other specimens, this is due to the fact that the presence of fiber with the filler increases the resistance of the material to the deformation and increases the forces and the binding between atoms or molecules increases the hardness of the material and thus increases its resistance to scratch [27, 31].

Table 8. Results hardness shore D for all specimens

Specimens	N	Mean	Std. Deviation	Minimum	Maximum	Sig.
UP	3	74.500	.9000	73.6	75.4	0.8
UP+5%J.F	3	76.667	.8505	75.8	77.5	0.6
Specimens with cinnamon stick powder						
UP+5%J.F+2%D.S	3	81.433	.8900	80.4	82.6	0.03
UP+5%J.F+5%D.S	3	83.633	.8083	82.9	84.5	0.01
UP+5%J.F+8%D.S	3	85.633	.8021	84.8	86.4	0.007
UP+5%J.F+11%D.S	3	87.667	.8055	86.9	88.5	0.001
Specimens with banana peels powder						
UP+5%J.F+2%B.P	3	81.533	.9504	80.6	82.5	0.05
UP+5%J.F+5%B.P	3	83.533	.6506	82.9	84.2	0.020
UP+5%J.F+8%B.P	3	85.433	.7767	84.8	86.3	0.008

UP+5%J.F+11%B.P	3	87.600	.7550	86.9	88.4	0.005

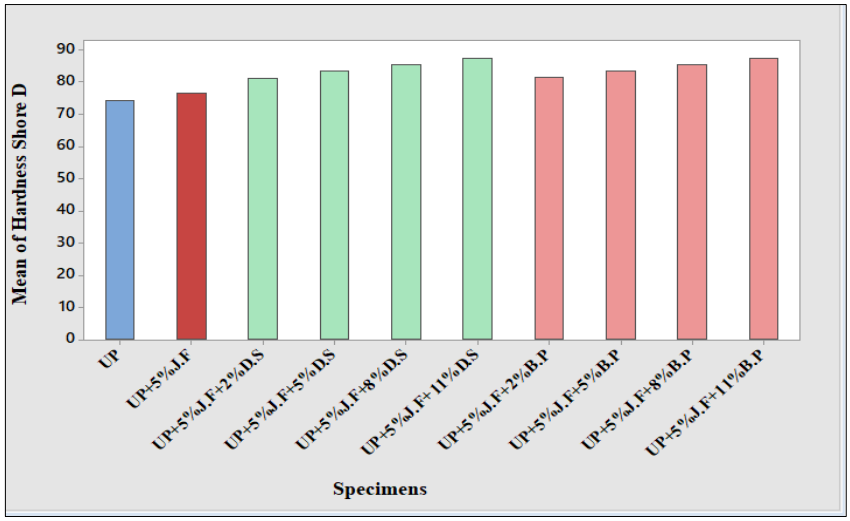


Figure 9. Results hardness shore D of all specimens

Water Absorption

Table 9 and Figure 10 represent the results of the water absorption of the hybrid composite specimens. The addition of jute fiber to the unsaturated polyester leads to rising water absorption because the water absorption depends on the mixing base and the density of jute fiber is higher than that of unsaturated polyester. The water absorption ratio of the specimens reinforced with cinnamon powder and banana peels powder was lower than the specimens (pure UP, UP +5% jute fibers), because the density of both cinnamon powder (0.52 gm/cm^3) and banana peel powder (0.71cm^3) was lower than that density of both unsaturated polyester (1.1 gm/cm^3) and jute fiber (1.46 gm/cm^3). The water absorption ratio of the specimens reinforced with the addition (2%, 5%, 8% and 11% wt.) cinnamon powder and banana peels powder increase because the addition of fillers increases moisture and reduces the adhesion between matrix material and reinforcement materials and thus makes hybrid composite contain more vacuums and porous [32]. The results showed that specimens reinforced by cinnamon powder have a water absorption ratio less when compared with specimens reinforced by banana peels powder, this is due to several reasons: small granular size of cinnamon powder compared with banana peels powder, the difference in density value, fewer pores and voids, good bonding between the matrix material and fillers, this agrees with [16, 33].

Table 9. Results water absorption for all specimens

Specimens	N	Mean	Std. Deviation	Minimum	**Maximum**	**Sig**
UP	3	0.07700	.002000	0.075	0.079	.314
UP+5%J.F	3	0.08533	.002517	0.083	0.088	.381
Specimens with cinnamon stick powder						
UP+5%J.F+2%D.S	3	0.04267	.002517	0.040	0.045	.010
UP+5%J.F+5%D.S	3	0.04900	.002000	0.047	0.051	.020
UP+5%J.F+8%D.S	3	0.05500	.002000	0.053	0.057	.076
UP+5%J.F+11%D.S	3	0.0603	.001528	0.059	0.062	.081

		3				
Specimens with banana peels powder						
UP+5%J.F+2%B.P	3	0.0550	.003000	0.052	0.058	.030
		0				
UP+5%J.F+5%B.P	3	0.0600	.002000	0.058	0.062	.042
		0				
UP+5%J.F+8%B.P	3	0.0670	.002000	0.065	0.069	.226
		0				
UP+5%J.F+11%B.P	3	0.0723	.002517	0.070	0.075	.228
		3				

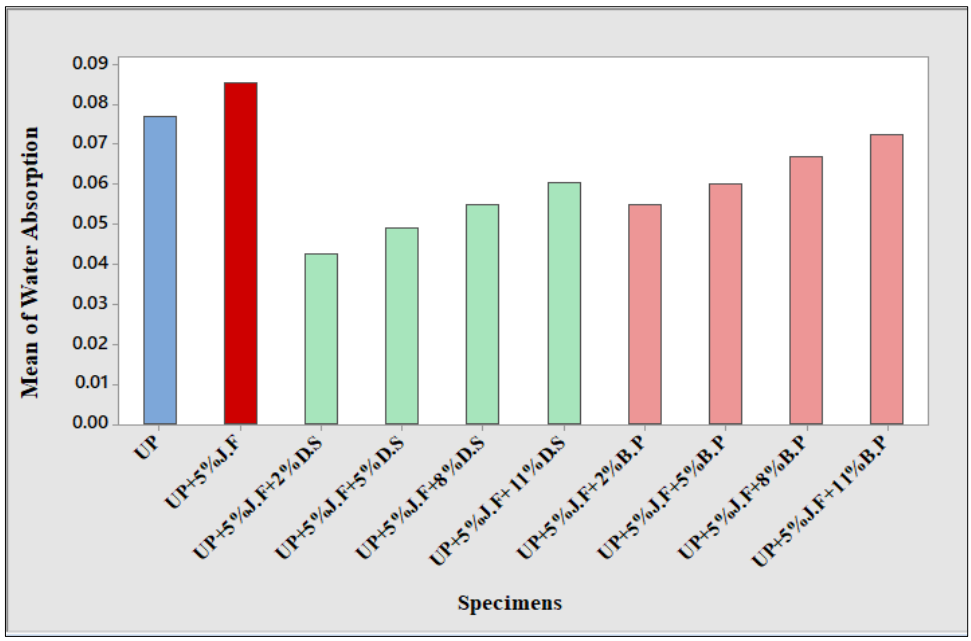


Figure 10. Results water absorption of all specimens

ANOVA Statistical Analysis

ANOVA statistical analysis (Tukey's posthoc and Scheffe) of test results of the flexural, impact, hardness shore D and water absorption of the specimens' hybrid composite is performed as shown in Table 10. The ANOVA analysis offers the difference into two components: a between-group component and a within-group component with significant. Results show the Sig value, of the flexural strength and flexural modulus for specimens reinforced with (cinnamon stick powder and banana peels powder), are .001, .002, .004, .006 respectively is less than 0.05. Results show the Sig value, of impact strength and toughness fracture for specimens reinforced with (cinnamon stick powder and banana peels powder), are .005, .008, .004, .006 respectively is less than 0.05. Results show the Sig value, of the hardness shore D and water absorption for specimens reinforced with (cinnamon stick powder and banana peels powder), are.001, .003, .03, .05 respectively is less than 0.05. This indicates that there is a statistically significant difference between the average flexural strength, flexural modulus, impact strength, toughness fracture, hardness shore D and water absorption from one level of the compound to another at the 95.0% confidence level. This means that the presence of jute fiber with cinnamon stick powder and banana peels powder has a positive effect on the properties this agrees with the references [23].

Table 10. ANOVA statistical analysis (Tukey's post-hoc and Scheffe) tests for all specimens

	Flexural Strength			
Specimens filled with	**Sum of**	**Df**	**Mean Square**	**Sig.**

cinnamon	**Squares**			
Between Groups	32398.500	5	6479.700	.001
Within Groups	112.000	12	9.333	
Total	32510.500	17		
Specimens filled with banana	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	29258.667	5	5851.733	.002
Within Groups	89.333	12	7.444	
Total	29348.000	17		
	Flexural Modulus			
Specimens filled with cinnamon	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	103.489	5	20.698	.004
Within Groups	.627	12	.052	
Total	104.116	17		
Specimens filled with banana	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	58.184	5	11.637	.006
Within Groups	.640	12	.053	
Total	58.824	17		
	Impact Strength			
Specimens filled with cinnamon	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	47.874	5	9.575	.005
Within Groups	.014	12	.001	
Total	47.888	17		
Specimens filled with banana	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	37.717	5	7.543	.008
Within Groups	.016	12	.002	
Total	37.734	17		
	Toughness Fracture			
Specimens filled with cinnamon	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	82.534	5	16.507	.004
Within Groups	.209	12	.017	
Total	82.743	17		
Specimens filled with banana	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	51.237	5	10.247	.006
Within Groups	.181	12	.015	
Total	51.418	17		
	Hardness Shore D			
Specimens filled with cinnamon	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	395.944	5	79.189	.001
Within Groups	9.393	12	.783	
Total	405.338	17		
Specimens filled with banana	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	387.498	5	77.500	.003
Within Groups	8.067	12	.672	
Total	395.564	17		
	Water Absorption			

Specimens filled with cinnamon	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	.004	5	.001	.03
Within Groups	.000	12	.000	
Total	.004	17		
Specimens filled with banana	**Sum of Squares**	**Df**	**Mean Square**	**Sig.**
Between Groups	.002	5	.002	.05
Within Groups	.000	12	.000	
Total	.002	17		

CONCLUSION

We extract the following results after conducting a realization of the mechanical and physical properties of the unsaturated polyester resin reinforced with jute, cinnamon stick powder and banana peels powder. Of the above results, detect the specimens (UP+5% J.F+ 11% cinnamon stick powder) and (UP+5% J.F+ 11% banana peels powder) leads to improve the flexural strength, flexural modulus, fracture toughness and hardness shore D of the specimens prepared, while the specimens (UP+5% J.F+ 8% cinnamon stick powder) and (UP+5% J.F+ 8% banana peels powder) leads to improve the impact strength of the specimens prepared. The water absorption percentage of specimens increase with the increasing of the weight fraction of reinforcement material, but water absorption decreases with decrease size particle therefore the specimens reinforced with cinnamon powder give water absorption percentage less than specimens reinforced with banana peels powder. ANOVA analysis showed that the significant differences in test results obtained from different compounds were positive because the value of (Sig) was less than (0.05).

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